What's a Fuel Cell?

Fuel cells use the chemical energy of hydrogen to generate electricity without combustion or pollution. The only by-products are pure water and useful heat.

What's all the excitement about?

More and more people are talking about hydrogen and fuel cells. You may have seen something about fuel cell-powered cars in the newspaper or heard about hydrogen on TV. So what's all the excitement about?

In the early 1900s, our country moved from horse-drawn transportation to vehicles powered by internal combustion engines. Today, we are in the early stages of another revolution, moving from engines that use fossil fuels (oil and gasoline) toward fuel cells that run on a clean fuel – hydrogen.

How will we use fuel cells?

Hydrogen fuel cells have the potential to power cars, trucks, and buses without producing harmful emissions. Vehicles powered by fuel cells will be cleaner and quieter, and consume less energy than those powered by internal combustion engines. And because the hydrogen used in fuel cells can be produced from a variety of sources, we won't need to rely on just one source of fuel for our transportation. Just imagine how different our world will be!

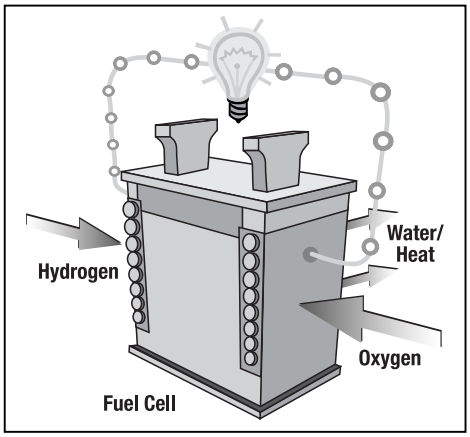
Fuel cells also may provide energy to factories, businesses, and homes without creating smokestack pollution. This adds up to energy savings for the consumer, energy security for our country, and a cleaner environment.

Scientists are developing many different types of fuel cells, but the most promising for use in automobiles is the lightweight, relatively small polymer electrolyte membrane (PEM) fuel cell. The PEM fuel cell's low-temperature operation lets it start quickly and increases its durability.

How does a fuel cell work?

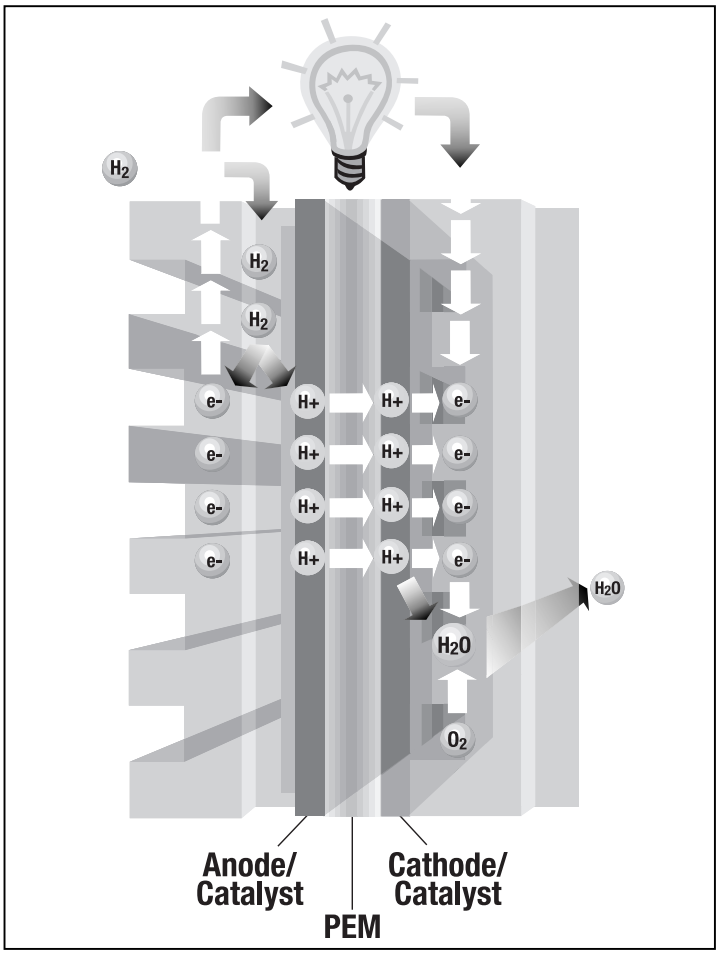
PEM fuel cells produce electricity directly from the electrochemical reaction between hydrogen fuel and oxygen from the air. Like car engines, PEM fuel cells turn fuel into power by doing something to the fuel to make it release energy.

In a regular car engine, what happens is combustion; the fuel burns in tiny explosions that push the pistons up and down. When a fuel burns, it is being "oxidized."



That is, the fuel combines with oxygen and the result is thermal (heat) energy. In a regular car (internal combustion) engine, the energy contained in the fuel is converted into heat and subsequently into mechanical motion, called kinetic energy, which turns the wheel. In a fuel cell, the fuel is also oxidized but without burning. This "electrochemical" process releases much of the fuel's energy in the form of useful electricity and heat. An electric motor turns the wheels.

A fuel cell power system has many components, but its heart is a fuel cell "stack." This stack is actually made of many thin, flat "cells" layered together. (The term "fuel cell" is often used to refer to the entire stack, but strictly speaking, it refers only to the individual cells.) A single cell produces a small amount of electricity, but many cells stacked together can provide enough to power a vehicle.



A single fuel cell consists of an "electrolyte membrane" sandwiched between two thin "catalyst layers," which help start the reactions that produce electricity. When hydrogen is fed to a PEM fuel cell and encounters the first catalyst layer, called the anode, the hydrogen molecules release electrons and protons. The protons migrate through the electrolyte membrane to the second catalyst layer, called the cathode, where they react with oxygen to form water. The electrons, however, can't pass through the electrolyte membrane to the cathode. Instead they must travel around it – this movement of electrons is an electrical current.

How does a PEM fuel cell compare to a combustion engine?

A fuel cell power system doesn't look, sound, or feel much like a regular engine; it doesn't have as many moving parts, it's nearly silent, it doesn't get as hot, and it needs fewer mechanical parts to move the vehicle.

PEM fuel cells are highly efficient! They can capture 50% or more of hydrogen's energy to power a car. The internal combustion engines in today's cars convert less than 20% of the energy in gasoline into power that moves the car. While automotive engineers have found ingenious ways to make internal combustion engines run more cleanly and efficiently, there's a limit to how good these engines can ever be.

A PEM fuel cell vehicle running on pure hydrogen produces only water vapor. Internal combustion engines, which run mostly on gasoline, produce troublesome amounts of soot, oxides of nitrogen, and carbon dioxide that contribute to smog and global warming.

When can I buy a fuel cell car?

Researchers are working to overcome a few key problems that must be solved before PEM fuel cells can be commonly used in automobiles. It's important to remember that fuel cell technology is still very new, while the internal combustion engine is 120 years old and is still being refined. Government and industry scientists are working to develop new technologies that will

- reduce the cost of producing, delivering, and storing hydrogen
- reduce the cost of producing the PEM fuel cell stacks
- increase durability and reliability in extreme operating conditions

For more information on the PEM fuel cell, visit www.eere.energy.gov/hydrogenandfuelcells/fuelcells/